

- PEARSON, T.G., C.S. BRIMLEY AND H.H. BRIMLEY. 1919. Birds of North Carolina. North Carolina geologic and economic survey. Vol. IV. Edwards and Broughton Printing Co., Raleigh, NC U.S.A.
- . 1942. Birds of North Carolina. North Carolina Department of Agriculture. Bynum Printing Co., Raleigh, NC U.S.A.
- RISEBROUGH, R.W. AND D.B. PEAKALL. 1988. The relative importance of several organochlorines in the decline of Peregrine Falcon populations. Pages 449–462 in T.J. Cade, J.H. Enderson, C.G. Thelander and C.M. White [Eds.], *Peregrine Falcon populations: their management and recovery*. The Peregrine Fund, Inc., Boise, ID U.S.A.
- STICKEL, L.F., S.N. WIEMEYER AND L.J. BLUS. 1973. Pesticide residues in eggs of wild birds: adjustment for loss of moisture and lipid. *Bull. Environ. Contam. Toxicol.* 9: 193–196.
- U.S. FISH AND WILDLIFE SERVICE. 1979. Eastern Peregrine Falcon recovery plan. Washington, DC U.S.A.
- . 1991. First update of Peregrine Falcon (*Falco peregrinus*), eastern population, revised recovery plan. Newton Corner, MA U.S.A.
- . 1995. Endangered and threatened wildlife and plants; advance notice of a proposal to remove the American Peregrine Falcon from the list of endangered and threatened wildlife. *Federal Register* 60: 34406–34409.
- WIEMEYER, S.N. 1996. Other organochlorine pesticides in birds. Pages 99–115 in W.N. Beyer, G.H. Heinz and A.W. Redmon-Norwood [Eds.], *Environmental contaminants in wildlife: interpreting tissue concentrations*. Lewis Publishers, Boca Raton, FL U.S.A.
- , R.D. PORTER, G.L. HENSLEY AND J.R. MAESTRELLI. 1986. DDE, DDT + dieldrin: residues in American Kestrels and relations to reproduction. USFWS, Fish Wildl. Tech. Rep. 6. Washington, DC U.S.A.

Received 23 January 1997; accepted 11 May 1998

J. Raptor Res. 32(3):254–256

© 1998 The Raptor Research Foundation, Inc.

IMPORTANCE OF BIRDS AND POTENTIAL BIAS IN FOOD HABIT STUDIES OF MONTAGU'S HARRIERS (*CIRCUS PYGARGUS*) IN SOUTHEASTERN SPAIN

JOSÉ A. SÁNCHEZ-ZAPATA AND JOSÉ F. CALVO

Departamento de Ecología e Hidrología, Facultad Biología, Universidad de Murcia, Campus de Espinardo, 30100 Espinardo, Murcia, Spain

KEY WORDS: *Montagu's Harrier*, *Circus pygargus*; diet; *mediterranean*.

Methods used to study the diets of raptors include the analysis of pellets, stomach contents, prey remains in nests or under perches, and direct observation of prey delivered to nests. In many species, including harriers (*Circus* spp.), analysis of prey remains only appears to underestimate the proportion of smaller prey and overestimate the occurrence of large prey (Schipper 1973, Simmons et al. 1991, Mañosa 1994, Real 1996). Several researchers have studied the diet of Montagu's Harrier (*Circus pygargus*) during the breeding season (Pérez-Chiscano and Fernández-Cruz 1971, Pérez-Chiscano 1974, Corbacho et al. 1995, Thiollay 1968, Helmich 1986), on migration (Castroviejo 1969), and while wintering (Cramp and Simmons 1980, Cormier and Baillon 1991). Extensive studies of their breeding diet in Spain (Hiraldo et al. 1975, Arroyo 1997), Holland and France (Schipper 1973), and Britain (Underhill-Day 1993) indicate that

small birds and mammals are important prey in northern and central Europe, whereas in southern Europe invertebrates appear to be numerically important, together with small birds (Underhill-Day 1993, Hiraldo et al. 1975). The goal of our study was to assess the importance of birds in the diet of Montagu's Harriers and to test how different study methods affect the results of such a food habits study.

STUDY AREA AND METHODS

The diets of three pairs of Montagu's Harriers breeding in a wadi or "rambla" in a mediterranean semiarid region in southeastern Spain (Suárez et al. 1996) were studied during 1995. Ajauque is a small wetland located in the most arid sector (average annual rainfall = 30 cm) of Murcia in southeastern Spain. Ajauque rambla drains an impermeable watershed of sedimentary marls. In arid and semiarid lands of the region, ramblas are more productive than surrounding lands owing to their vegetation that consists mainly of reeds (*Phragmites australis*) and halophytic plants. The Ajauque rambla is part of a protected

Table 1. Montagu's Harrier prey during courtship (April), incubation (May), nestling (June), and fledging (July) periods, and all data pooled (All). Proportion of each prey and prey group by number (%) and by weight (%W).

PREY	APRIL	%	MAY	%	JUNE	%	JULY	%	ALL	%	%W
BIRDS	22	59	31	68	15	44	13	59	81	58	86
<i>Carduelis chloris</i>	1	3	0	0	1	3	0	0	2	1	3
<i>Carduelis carduelis</i>	0	0	1	2	1	3	0	0	2	1	2
<i>Carduelis</i> spp.	2	5	0	0	2	7	1	5	5	4	5
<i>Galerida theklae</i>	2	5	0	0	0	0	0	0	2	1	3
<i>Galerida</i> sp.	1	3	1	2	1	3	2	9	5	4	8
<i>Calandrella rufescens</i>	1	3	0	0	0	0	0	0	1	1	1
<i>Alaudidae</i> ind.	1	3	9	20	1	3	0	0	11	8	14
<i>Cisticola juncidis</i>	0	0	0	0	1	3	0	0	1	1	1
<i>Saxicola torquata</i>	0	0	0	0	3	9	3	13	6	4	4
Unidentified passerine	14	38	20	44	5	15	7	32	46	33	45
REPTILES	4	11	7	15	4	12	1	5	16	11	7
<i>Psammodromus algirus</i>	2	5	2	4	0	0	0	0	4	3	2
Unidentified lizzard	2	5	5	11	4	12	1	5	12	8	6
MAMMALS	0	0	2	4	0	0	0	0	2	2	5
<i>Mus</i> spp.	0	0	1	2	0	0	0	0	1	1	1
<i>Oryctolagus cuniculus</i>	0	0	1	2	0	0	0	0	1	1	4
INVERTEBRATES	11	30	6	13	15	44	8	36	40	29	2
<i>Anacridium aegyptium</i>	7	19	0	0	5	15	0	0	12	9	2
Unidentified Orthoptera	0	0	2	4	1	3	2	9	5	3	0
<i>Orites nasicornus</i>	1	3	0	0	0	0	0	0	1	1	0
Unidentified Coleoptera	0	0	4	9	7	21	5	22	16	12	0
Unidentified invert.	3	8	0	0	2	6	1	5	5	4	0
TOTAL	37		46		34		22		139		

area that includes 69.4 ha of wetland where 3–5 pairs of Montagu's Harriers regularly breed on dense salty-shrub (*Sarcocornia fruticosa* and *Scirpus* spp.) and hunt in surrounding shrubsteppes and cropland.

We divided the breeding season into four periods of approximately 30 d each: courtship period (April), incubation period (May), nestling period (June), and fledging period (July). We used three different methods to assess food habits: (1) we collected pellets found under perches used by male harriers, (2) we collected prey remains found under perches used by both males and females, and (3) we identified prey during aerial transfers by males to females and young. Perches were visited weekly during the breeding period and all prey remains were identified and removed. Prey were identified using reference collections. Weights of prey were assigned following Hiraldo et al. (1975) and Donazar (1988). We used percentage uniformity tests (Sokal and Rohlf 1969) to compare the different diets determined using the different study methods.

RESULTS AND DISCUSSION

When we pooled all the data, small birds were the most numerous prey (58%) followed by invertebrates (29%), lizards (12%), and mammals (1%) (Table 1). Overall, small birds including small land, shrub and edge-nesting passerines (Thela lark, *Galerida theklae*, Lesser Short-toed Lark, *Calandrella rufescens*; Common Stonechat, *Saxicola*

torquata; Citting Cisticola, *Cisticola juncidis*; and finches, *Carduelis* spp.) made up to 84% of the prey by weight. During the courtship and incubation periods, nestling passerines and eggs accounted for 60–86% of the birds eaten. Orthopterans and coleopterans were the second prey group by number, followed by a small lizard *Psammodromus algirus* which is the most common lizard species in salty shrub-steppes in southeastern Spain (Hernández et al. 1993). Small mammals occurred infrequently in the diet probably because of their low densities and nocturnal nature, especially in arid and semiarid Mediterranean regions (Herrera and Hiraldo 1976, Sánchez 1994).

The proportion of birds found in pellet samples (48%, $N = 83$) was smaller than in samples of prey remains (78%, $N = 37$) and aerial transfers (72%, $N = 19$), though there were only significant differences between pellets and prey remains ($t = 3.23$, $df = 2$, $P = 0.0012$). Several authors have suggested that pellets provide a less biased source of information on raptor diets because many prey species found in pellets are seldom found in prey remains at nests or under perches (Schipper 1973, Simmons et al. 1991, Real 1996). Because pellet samples underestimated the number of small birds in our study, it seems that the opposite appears to be true in the diet of Montagu's Harriers. Most of bird prey recorded were nestlings or juveniles which are easy to digest and diffi-

cult to find in pellets (Underhill-Day 1993), whereas invertebrate and lizard remains such as scales in pellets were easily detected. Birds have also been shown to be the main prey of Montagu's Harriers both in terms of numbers and weight in most of Europe during the breeding season (Schipper 1973, Hiraldo et al. 1975, Underhill-Day 1993, Corbacho et al. 1995, Arroyo 1997). Small mammals such as voles (*Microtus* spp.) and young hares (*Lepus* spp.) have been shown to be only locally or temporally important (Thiollay 1968, Arroyo 1997) even though most studies have only considered pellets.

RESUMEN.—Se analiza la dieta del Aguilucho cenizo en un humedal del Sureste de España durante el periodo reproductor utilizando tres métodos diferentes; egagrópilas, restos de presas en posaderos y transferencia de presas. Los pájaros se revelan como el componente principal de la dieta tanto en número como en biomasa, seguidos por los invertebrados y reptiles. Se observaron sesgos en la proporción de aves que aparecen en la dieta según el método de estudio.

[Traducción Autores]

ACKNOWLEDGMENTS

This study had financial support from the Dirección General del Medio Natural of Murcia Region and LIFE projects (UE). Sergio Eguía, Andrés Giménez, Javier Royo, José María Caballero, José Joaquín Hernández, Asunción Andreu and Trino Ferrández helped during the field work. Andrés Millán and Eulalia Clemente helped to identify invertebrate remains. José Antonio Donázar revised an early draft and Beatriz Arroyo, Keith L. Bildstein and an anonymous referee made valuable comments on the manuscript.

LITERATURE CITED

- ARROYO, B.E. 1997. Diet of Montagu's Harrier *Circus pygargus* in central Spain: analysis of temporal and geographic variation. *Ibis* 139:664–672.
- CASTROVIEJO, J. 1969. Sobre paso y alimentación de *Circus pygargus* en el NW de España. *Ardeola* 14:216–217.
- CORMIER, J.P. AND F. BAILLON. 1991. Concentration de busards cendrés *Circus pygargus* (L.) dans la région de 'bour (Sénégal) durante l'hiver 1988–1989: utilisation du milieu et régime alimentaire. *Alauda* 59:163–168.
- CORBACHO, C., A. MUÑOZ AND P. BARTOLOMÉ. 1995. Espectro trófico del aguilucho cenizo (*Circus pygargus* L.) en Extremadura. *Alytes*:441–448.
- CRAMP, S. AND K.E. SIMMONS. 1980. The birds of western Palearctic, Vol. II. Oxford Univ. Press, Oxford, U.K.
- DONÁZAR, J.A. 1988. Variaciones en la alimentación entre adultos reproductores y pollos en el Búho Real (*Bubo bubo*). *Ardeola* 35:278–284.
- HELMICH, J. 1986. Notas sobre el ritmo de actividad y la alimentación del aguilucho cenizo en Agosto y Septiembre en Extremadura. *Alytes* 5:69–79.
- HERNÁNDEZ, V.F. DICENTA, F. ROBLEDANO, M. GARCÍA, M.A. ESTEVE AND L. RAMÍREZ. 1993. Anfibios y reptiles de la Región de Murcia. Cuadernos de Ecología y Medioambiente, No. 1. Univ. Murcia, Murcia, Spain.
- HERRERA, C.M. AND F. HIRALDO. 1976. Food niche and trophic relationships among European owls. *Ornis Scand.* 7:29–41.
- HIRALDO, F., F. FERNANDEZ AND F. AMORES. 1975. Diet of the Montagu's Harrier (*Circus pygargus*) in southwestern Spain. *Doñana Acta Vertebrata* 2:25–55.
- MAÑOSA, S. 1994. Goshawk diet in a Mediterranean area of northeastern Spain. *J. Raptor Res.* 28:84–92.
- PÉREZ-CHISCANO, J.L. 1974. Sumario informe sobre alimentación de rapaces en el NE de Badajoz. *Ardeola* 19:331–336.
- AND M. FERNÁNDEZ-CRUZ. 1971. Sobre *Grus grus* y *Circus pygargus* en Extremadura. *Ardeola*, Vol. Especial: 509–574.
- REAL, J. 1996. Biases in diet study methods in the Bonelli's Eagle. *J. Wildl. Manage.* 60:632–638.
- SÁNCHEZ, J.A. 1994. Ecología de las aves de presa de la región de Murcia. M.S. thesis, Univ. Murcia, Murcia, Spain.
- SCHIPPER, W.J.A. 1973. A comparison of prey selection in sympatric harriers (*Circus*) in western Europe. *Le Gerfaut* 63:17–120.
- SIMMONS, R.E., D.M. AVERY AND G. AVERY. 1991. Biases in diets determined from pellets and remains: correction factors for a mammal and bird-eating raptor. *J. Raptor Res.* 25:63–67.
- SOKAL, R.R. AND F.J. ROHLF. 1969. Biometry. Freeman and Co., San Francisco, CA U.S.A.
- SUÁREZ, M.L., M.R. VIDAL, J.F. CALVO, M.A. ESTEVE, R. GÓMEZ, A. GIMÉNEZ, J.A. PUJOL, J.A. SÁNCHEZ, M. PARDO, J. CONTRERAS AND L. RAMÍREZ. 1996. Zone humide d'Ajauque-Rambla Salada. Pages 40–52 in C. Morillo and J.L. Gonzalez [Eds.], Management of Mediterranean wetlands, III. Ministerio de Medio Ambiente, Gran Vía San Francisco, Madrid.
- THIOLLAY, J.-M. 1968. La pression de predation estivale du busard cendré *Circus pygargus* L. sur les populations de *Microtus arvalis* en Vendée. *Terre Vie* 22:321–342.
- UNDERHILL-DAY, J.C. 1993. The foods and feeding rates of Montagu's Harriers *Circus pygargus* breeding in arable farmland. *Bird Study* 40:74–80.

Received 6 August 1997; accepted 19 May 1998